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Management

Environmental
Protection
Branch

Surface Water Quality Objectives

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Foreword

This document is a reprint of the 1988 edition of the *Surface Water Quality Objectives* (Saskatchewan Environment and Public Safety 1988, WQ110). It has been revised only with respect to updating the names, addresses and telephone numbers of agency contacts.

The earlier editions primarily concerned multi-purpose objectives to protect most beneficial water uses. The present publication addresses:

1. General Objectives for effluent discharges (Section 3).
2. Guidelines for effluent mixing zones (Section 3.1).
3. General surface water quality objectives (Section 4.1).
4. Specific surface water quality objectives respecting aquatic life, wildlife, recreational activities, agricultural uses, and potable water supply (Section 4.2).

The objectives presented in the following chapters have been developed using available scientific literature and water quality criteria. The Canadian Water Quality Guidelines (CCREM 1987) as well as numerous water quality criteria publications of the United States Environmental Protection Agency were utilized as major information sources.

This booklet is primarily oriented towards surface water quality. The objectives are also applicable to ground waters which are utilized for specific purposes addressed in this report.

There are many instances where the natural water quality of a lake or river does not meet some of the objectives. In these cases, the objectives obviously will not apply. It should be noted, however, that where the natural existing quality is inferior to desirable objectives, it would be unwise to permit further deterioration by unlimited or uncontrolled introduction of pollutants. Naturally occurring circumstances are not taken into account in these "Objectives" and due consideration must be given where applicable (eg. spring runoff effect on colour, odour, ice and snow cover effect on dissolved oxygen and influences on major ion levels; rainfall influences on bacteria levels in surface waters).

In the future the Department will be revising these objectives as improved knowledge of various constituents/conditions becomes available. Also, additional use-specific objectives and basin specific objectives may be developed for different basins characterized by different water quality characteristics.

Municipal drinking water quality objectives are contained in a separate booklet published by the Department.

Please forward inquiries concerning the objectives to:

**Environmental Protection Branch
Saskatchewan Environment and
Resource Management
Rm. 204, 3211 Albert Street
Regina, Saskatchewan S4S 5W6
Phone: 787-6232**

1. General Policy

The goals of the water quality management policy of the Department are to conserve water and to protect, maintain and improve its quality for the protection of public health and, within economic limits, for the following purposes:

- preservation and protection of water supplies;
- encouragement of economic development;
- preservation of aesthetic values; and
- preservation of fish and wildlife.

The Department has not set "across the board" effluent standards, except for parts of the mining industry. It has chosen instead to examine each case of waste disposal and water pollution on its own merits considering each case from the broader water quality management point of view. Guidelines or objectives are, of course, necessary to assist in the evaluation of each case and these are contained in the following comments and tables. Interpretation is based on field data, the various uses of the water body in question and the effects thereon, and the practicability of treatment.

The factors that influence the degree of pollution and which are used to assess the degree of treatment required include, in addition to the nature and volume of the polluting waste, the effects of pH, climate, assimilative capacity, natural quality and character of the receiving water, mixing, chemical and biological changes, velocity of flow, specific requirements of various beneficial uses and other variables.

Each substance that may enter a body of water is deemed to be a potential pollutant - potential in the sense that if concentrated

sufficiently, it can adversely and unreasonably affect such waters for one or more beneficial uses and yet if treated and assimilated adequately it will be harmless to all beneficial uses. The concentration of these potential pollutants in water is a function not only of the amount of polluting substance added but also of the factors of dilution, self-purification, synergism and antagonism.

There are requirements that may be specified as universally applicable (e.g. General Objectives for Effluent Discharges, Section 3) without any need for studies or surveys. They represent the minimum conditions that should be achieved regardless of any other circumstances and are justified on the basis of aesthetics and practicable treatment technology. To meet these conditions a minimum degree of treatment of all wastewaters/sewages will be required before effluent discharges will be approved. In addition, there may be supplementary requirements concerning effluent treatment, effluent quality and the manner of discharge, in order to protect various uses of receiving waters. The determination of the extent of supplementary requirements is made on a case-by-case basis and may involve time for data assembly and evaluation.

In the consideration of an application to build a new works or to improve existing works, the Department will be guided by the Water Quality Objectives.

The Department will attempt to provide technical assistance and advice in order to help applicants resolve their water quality problems.

2. Uses of Water Quality Objectives

The water quality objectives described herein are intended for the following applications.

Protection of Water Quality

Water quality is monitored by the Department from a network of sites throughout the province as well as from intensive surveys conducted at selected waterbodies. These data are evaluated to identify trends and emerging problems so that corrective steps can be taken. Where the objectives are achieved the water quality can be considered suitable for the specific uses likely to occur on each waterbody examined.

Effluent Mixing Zones

A portion of an effluent receiving waterbody may be utilized for the purpose of providing an initial dispersal of treated effluent. This area, nearest the effluent outfall is known as the mixing zone (see Section 3.1). Water quality objectives, receiving water quantity and quality characteristics and water use information for

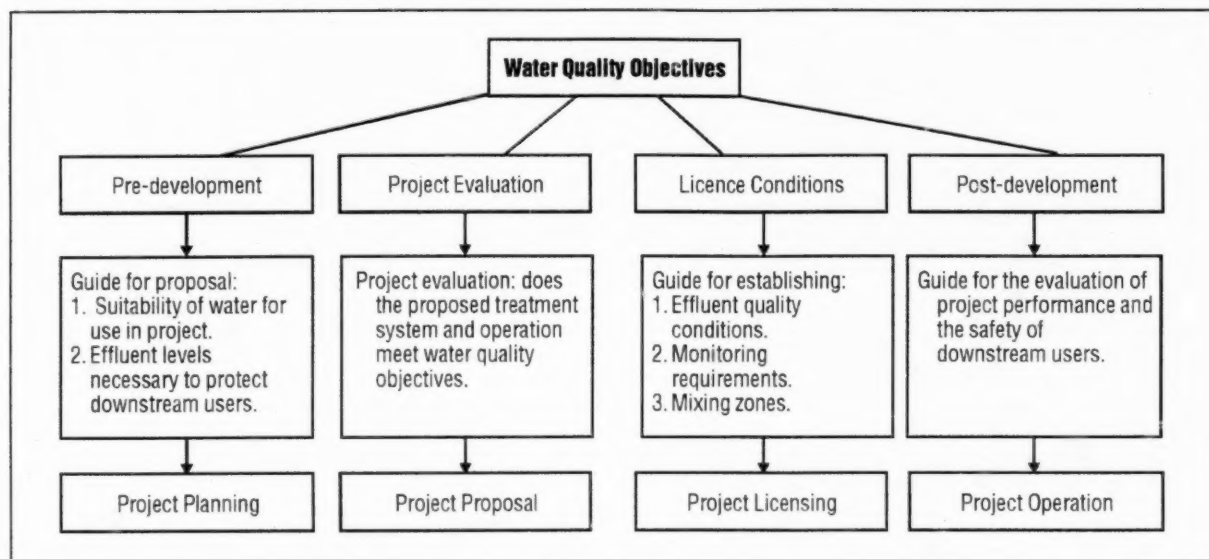
the receiving waterbody are used to determine the acceptable size and shape of the mixing zone.

Advice to Water Users

Water quality objectives are used to provide advice to water users requiring information on the suitability of water sources for such purposes as recreation, livestock water, fish rearing, irrigation and others.

Environmental Assessment/Effluent Treatment

Water quality objectives are used extensively in evaluating development proposals, in setting effluent treatment requirements, and in evaluating the performance of treatment works. These issues are summarized in the diagram on the following page.



3. Objectives for Effluent Discharges

3.1 General Objectives

The following basic objectives are applicable to all waters receiving effluents, **including the mixing zones adjacent to effluent outfalls** (see Section 3.1) in the context that municipal, industrial, agricultural and other discharges should be:

- (1) free from substances in concentrations or combinations which are acutely toxic or may be harmful to human, animal or aquatic life;
- (2) free from substances that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl;
- (3) free from debris, oil, grease, scum or other materials in amounts sufficient to be noticeable in the receiving water;
- (4) free from colour, turbidity or odour-producing materials that would:
 - (a) adversely affect aquatic life or waterfowl;
 - (b) significantly alter the natural colour of the receiving water;
 - (c) directly or through interaction among themselves or with chemicals used in water treatment, result in undesirable taste or odour in treated water, and;
- (5) free from nutrients in concentrations that create nuisance growths of aquatic weeds or algae or that results in an unacceptable degree of eutrophication of the receiving water;
- (6) in addition to the above objectives, effluent discharged to surface waters should not utilize more than 30 percent of the assimilation capacity of the receiving waterbody when

discharged via means of a diffused outfall, or more than 10 percent when discharged via a point source outfall. These design objectives should be utilized during the planning stages of projects involving effluent discharges. For purposes of determining the available assimilation capacity of a receiving waterbody, a flow rate equal to or less than the average seven day low flow which occurs once in ten years (e.g. 7Q10), at the outfall area, generally should be used.

3.2 Guidelines for Effluent Mixing Zones

A mixing zone is a region of a waterbody in which an effluent discharge of quality (chemical/physical/biological) characteristics different from those of the receiving water is in transit and is progressively assimilated from the immediate outfall area to the outer limits of the region. Portions of the mixing zone may be considered a "limited use zone" with respect to water use. At the boundaries or outer limits of the limited use zone, water quality objectives established by the Department to protect beneficial water uses should be achieved.

The effluent mixing zone guidelines are intended for application to larger surface waterbodies. However, they also have limited application to some intermittent streams and small lakes which have sufficient flow or volume of water, at least seasonally, to adequately assimilate periodic discharges of treated wastewater effluent. Generally, the average 7-day low flow occurring at a frequency of once in 10 years (e.g. 7Q10 flow) at the outfall site will be used to assess assimilation in the mixing zone.

The guidelines should be applied by proponents during the planning and design stages of new developments involving effluent discharge(s) or changes in the flows/volumes of water available for effluent assimilation, and for current dischargers where alterations of the existing wastewater treatment or disposal system are proposed. These guidelines prescribe the general characteristics that mixing zones should or should not possess.

Effluent Mixing Zone Guidelines

- (1) The mixing zone should be as small as practicable and should not be of such size or shape as to cause or contribute to the impairment of existing or likely water uses;
- (2) The existing General Objectives for Effluent Discharges (Section 3) should be achieved at all sites within the limited use zone;
- (3) The limited use zone in streams and rivers should be apportioned no more than 25 percent of the cross-sectional area or volume of flow, nor more than one-third of the river width at any transect in the receiving water during all flow regimes which equal or exceed the 7Q10 flow for the area. Surface water quality objectives **applicable to the area** must be achieved at all points along a transect at a distance downstream of the effluent outfall to be determined on a case-by-case basis;
- (4) In lakes and other surface impoundments, surface water quality objectives applicable to that waterbody must be achieved at all points beyond a radius of 100 metres from the effluent outfall. The volume of limited use zones in lakes should not exceed 10 percent of that part of the receiving waters available for mixing;
- (5) The mixing zone should be designed to allow an adequate zone of passage for the movement or drift of all stages of aquatic life; specific portions of a cross-section of flow or volume may be arbitrarily allocated for this purpose;
- (6) Mixing zones should not interfere with the migratory routes, natural movements, survival, reproduction, growth, or increase the vulnerability to predation, of any representative aquatic species, or endangered species;
- (7) Mixing zones should not interfere with fish spawning and nursery areas;
- (8) When two or more mixing zones are in close proximity, they should be so defined that a continuous passageway for aquatic life is available;
- (9) When two or more mixing zones overlap the combination of the effluent plumes should not result in unacceptable synergistic or antagonistic effects on aquatic life or other water uses downstream of the mixing zone(s);
- (10) Mixing zones should not cause an irreversible organism response or attract fish or other organisms and thereby increase their exposure period within the zone;
- (11) The 96 hr LC₅₀ toxicity criteria, for indigenous fish species and other important aquatic species should not be exceeded at any point in the mixing zones;
- (12) Mixing zones should not result in contamination of natural sediments so as to cause or contribute to excursions of the water quality objectives outside the mixing zone;
- (13) Mixing zones should not intersect domestic water supply intakes, bathing areas or other sensitive designated use areas, and;
- (14) Specific numerical water quality objectives may be established by the Department for such variables or constituents thought to be of significance within the effluent mixing zone.

4. Surface Water Quality Objectives

Two types of surface water quality objectives are addressed in the following passages. The first, **General Surface Water Quality Objectives**, concerns basic quality characteristics which will afford a minimum degree of protection of all beneficial uses of surface waterbodies, including those used for effluent assimilation. These objectives include both narrative and numerical values for various constituents or conditions.

The second type of objectives address precise numerical values for various constituents or conditions which need to be achieved in order to protect waterbodies for specific water uses. These **Specific Surface Water Quality Objectives** address quality requirements for such water uses as aquatic life and wildlife, recreation, irrigation and livestock watering.

4.1 General Surface Water Quality Objectives

These objectives (Table 4.1) are applicable to all portions of a receiving waterbody except that portion designated by the Department as an effluent mixing zone. Within the mixing zone, however, the General Objectives for Effluent Discharges (Section 3) apply.

These objectives are useful in the protection of all water uses, including the protection of waters to be withdrawn and treated as a potable supply.

The **General Surface Water Quality Objectives** are not applicable to intermittent streams except during flow periods such as spring runoff. These objectives should be achieved, however, in portions of intermittent streams where ponded stream water is utilized for beneficial purposes (e.g. irrigation, fish rearing, cattle watering, etc.).

4.2 Specific Surface Water Quality Objectives

The specific objectives presented below provide a means for evaluation of water quality conditions except in areas of a waterbody in close proximity to outfalls (e.g. within limited use zones, Section 3.2). In the vicinity of outfalls a "zone of passage" of satisfactory quality must be considered for aquatic biota travel. In waters of superior quality, impairment to the objective levels will not be acceptable.

Table 4.1: General Surface Water Quality Objectives

Parameter	Objectives
Bacteria:	
Total Coliforms	Not to exceed a density of 5,000 per 100 mL in any sample.
Fecal Coliforms	Not to exceed a density of 1,000 per 100 mL in any sample.
Biochemical Oxygen Demand (BOD ₅)	Dependent on the assimilative capacity of the receiving water. The BOD must not exceed a limit which would create a dissolved oxygen content of less than five mg/L.
Colour (apparent)	Not to be increased by more than 30 colour units above ambient natural value.
Flow	Water quantities (flow and lake levels) should not be altered unreasonably so as to result in water quality impairment such that water uses are adversely affected.
Major Ions	The predominant cations of sodium, calcium, and magnesium, and anions of sulphate, chloride, and bicarbonate are too variable in the natural water quality state to attempt to define objectives. In general, however, levels of these major ions should not be suddenly increased or decreased in a receiving water so as to result in injury to aquatic life, or alter the sodium:cation ratio beyond the range of 0.30 to 0.75.
Nutrients	Nitrogen or phosphorus or other nutrient concentrations should not be altered from natural levels by discharges of effluents such that nuisance growths of algae or aquatic weeds result.
Oxygen (dissolved)	A minimum of five mg/L at any time.
Pesticides	To provide reasonably safe concentrations of these materials in receiving waters an application shall not exceed 1/100 of the 96 hr LC ₅₀ . Consideration must also be given to sublethal effects and to objectionable taste and odour generation, and to tainting of fish flesh.
pH	To be in the range of 6.5 to 8.5 pH units but not altered by more than 0.5 pH units from ambient values.
Radium 226	0.11 Bq/L
Suspended Solids	Not to be increased by more than 10 mg/L over existing background values for waters with levels of less than 100 mg/L, or not to be increased by more than 10 percent over existing values for waters with levels greater than 100 mg/L.
Sulphide	0.01 mg/L
Turbidity	Not to be increased by more than 25 turbidity units above ambient value.

4.2.1 Aquatic Life and Wildlife

Objectives for protecting the quality of the habitat of aquatic organisms including fish, aquatic fauna and flora, are often more stringent than those applicable to other water uses. These objectives (Table 4.2) will afford a reasonable degree of protection of fish and other aquatic life at all stages of development. Because of the relatively stringent values for various constituents these objectives will also likely afford protection to wildlife which rely upon surface water for drinking water and for their source of food supply.



4.2.2 Recreational Uses

Although the use of surface waters for personal drinking water supply is not addressed in this report, recreationists are cautioned not to consume surface waters without prior

disinfection (e.g. boiling, chlorination) of the water. Even waters which appear to be pristine may contain naturally occurring disease-causing micro-organisms.



4.2.2.1 Contact Recreation

Contact recreational use of water concerns those activities which involve direct contact between the human body and surface water for prolonged periods or activities where ingestion/inhalation of

surface water is likely to occur. Such activities include swimming, water skiing, bathing and wading. These objectives (Table 4.3) will afford reasonable protection of water users from waterborne disease and maintain desirable aesthetic conditions in the waterbody.

Table 4.2: Specific Surface Water Quality Objectives for the Protection of Aquatic Life and Wildlife

Parameter	Objectives (values are in mg/L unless otherwise stated)
Inorganic Constituents	
Total Ammonia Nitrogen (mg/L)	Note: The toxicity of ammonia relates primarily to the unionized form (NH_3). The concentration of unionized ammonia present in water increases with pH and temperature. The values below represent total ammonia-nitrogen concentrations (at various temperatures and pH levels) above which accompanying NH_3 concentrations may be harmful to aquatic life.
Total Ammonia ($\text{NH}_3 + \text{NH}_4^+$) (maximum levels expressed as N at various pH/temperature conditions)	
pH (pH units)	Water Temperature ($^{\circ}\text{C}$)
	0 5 10 15 20 25 30
6.50	2.06 1.97 1.81 1.81 1.22 0.85 0.60
6.75	2.06 1.97 1.81 1.81 1.22 0.85 0.61
7.00	2.06 1.97 1.81 1.81 1.22 0.85 0.61
7.25	2.06 1.97 1.81 1.81 1.23 0.86 0.61
7.50	2.06 1.97 1.81 1.81 1.23 0.87 0.62
7.75	1.89 1.81 1.73 1.64 1.15 0.81 0.58
8.00	1.26 1.18 1.13 1.09 0.76 0.54 0.39
8.25	0.72 0.67 0.64 0.62 0.44 0.32 0.23
8.50	0.40 0.39 0.37 0.37 0.26 0.19 0.15
8.75	0.23 0.22 0.21 0.22 0.16 0.12 0.09
9.00	0.13 0.13 0.13 0.13 0.11 0.08 0.06
Arsenic (total)	0.05
Barium (total)	1.0
Cadmium (total)	0.001
Chlorine (total residual)	0.002
Chromium (total)	0.020
Copper (total)	0.01
Cyanide (total)	0.01
Iron (total)	1.0
Lead (total)	0.02
Mercury (total)	0.0001
Nickel (total)	0.025 mg/L where hardness ≤ 100 mg/L (CaCO_3) 0.100 mg/L where hardness > 100 mg/L (CaCO_3)
Oxygen (dissolved)	6.0 - Protection of early life stage of warm water biota 5.0 - other life stages of warm water biota 9.5 - early life stages of cold water biota 6.5 - other life stages of cold water biota
Selenium (total)	0.01
Silver (total)	0.01
Temperature	not to be altered by more than 3°C from ambient water temperature
Zinc (total)	0.05
Lindane (gamma BHC)	0.0001
Pentachlorophenol	0.0005
Phenols (total)	0.001
Phenoxy herbicides (2,4-D)	0.004
Polychlorinated biphenyls (total)	0.000001
Unspecified Substances	To provide reasonably safe concentrations of substances not specifically addressed in the above objectives, a general objective of 1/100 of the 96 hour LC_{50} of such substances shall be applied. Consideration will also be given to such effects as objectionable taste and odour generation and tainting flesh of aquatic life.

Table 4.3: Specific Surface Water Quality Objectives for the Protection of Contact Recreational Use

Parameter	Objectives
Clarity	Bathing waters should be sufficiently clear that a Secchi disc is visible at a depth of 1.2 m.
Fecal Coliforms	-not to exceed a geometric mean density of 200 per 100 mL. -not to exceed a density of 200 per 100 mL in more than 20 percent of samples. Note: The values should be based on at least five samples obtained over a 30 day period. A fecal coliform density of more than 400 per 100 mL in any sample should be followed up immediately by repeat analysis and sanitary inspection to determine the probable cause of contamination.

4.2.2.2 Non-Contact Recreation

Non-contact recreational use of water concerns those activities in which ingestion or inhalation or prolonged contact with surface water is not likely to occur. Such activities include boating, fishing and camping.

**Table 4.4: Specific Surface Water Quality Objectives for the Protection of Non-Contact Recreational Use**

Parameter	Objectives
Total Coliforms	-not to exceed a density of 5,000 per 100 mL in any sample.
Fecal Coliforms	-not to exceed a density of 1,000 per 100 mL in any sample.

4.2.3 Agricultural Uses

4.2.3.1 Crop Irrigation

The water quality objectives in Table 4.5 have been prepared to afford long-term protection of all agricultural soils and most crops likely to be irrigated on a continuous basis. They are also intended to protect the health of human and animal consumers of irrigated crops.

Supplementary information tables (Tables 4.6 - 4.10) provide an indication of the relative tolerances of different soil types and crop species to higher levels of constituents than those prescribed in the objectives.

These objectives may be too restrictive under some conditions such as those where irrigation is used mainly to supplement rainfall, where well drained, coarse-textured soils predominate, or where tolerant plant species may be cultured. Innovative irrigation management and crop cultural practices can also permit the use of waters with higher levels of constituents (e.g. ground waters, effluents) than prescribed in the objectives.

In southern Saskatchewan, as in other prairie environments, much of the surface and ground waters and effluents which are potentially available for crop irrigation are highly mineralized. These waters may contain elevated levels of salts, specific ions (e.g. sodium, chloride, bicarbonate), boron and other constituents (e.g. trace metals) which may restrict the use of such waters for irrigation of only certain soil types or crop species. This topic is addressed in greater detail in the report "Irrigation Water Quality - Soil Compatibility Guidelines for Irrigation in Saskatchewan" (Saskatchewan Water Corporation 1988).



Since different soils and plant species vary considerably in the quality of water each may tolerate, irrigators are advised to contact the Saskatchewan Water Corporation and Soil Science Department of the University of Saskatchewan (See Section 6 for contacts) for advice regarding site-specific irrigation and cultural practices that would be best suited to the soil types and quality of waters available to them.

In situations where wastewater irrigation is considered, irrigators should also refer to the "Sewage Effluent Irrigation Guidelines", (Saskatchewan Environment, 1983).

Table 4.5: Specific Surface Water Quality Objectives for the Protection of Irrigation Use
(values are in mg/L unless otherwise stated)

Parameter	Objective	Comment
Aluminum (total)	5.0	
Arsenic (total)	0.1	
Bacteria:		
Total Coliforms	1,000 per 100 mL	These levels are specifically intended to afford protection of consumers of raw fruits and vegetables irrigated with surface waters. Higher levels of bacteria may be acceptable for irrigation of crop species which are utilized for livestock feed or which undergo extensive processing or cooking prior to consumption. In situations where wastewater irrigation is considered, irrigators should refer to the "Sewage Effluent Irrigation Guidelines", (Saskatchewan Environment, 1983).
Fecal Coliforms	100 per 100 mL	
Beryllium (total)	0.1	
Boron (total)	0.5	- see Table 4.10 for crop tolerances to boron.
Cadmium (total)	0.01	
Chloride (total)	100	- see Tables 4.6, 4.7 for crop tolerances to chloride.
Chromium (total)	0.1	
Cobalt (total)	0.05	
Copper (total)	0.2	
Fluoride (total)	1.0	
Iron (total)	5.0	
Lead (total)	0.2	
Lithium (total)	2.5	
Manganese (total)	0.2	
Molybdenum (total)	0.01	
Nickel (total)	0.2	
Selenium (total)	0.02	
Sodium	100	- see Tables 4.7, 4.8.
Sodium Adsorption Ratio (SAR)	Soil Texture	- see Table 4.8 and Figure 4.1.
	<4.0 heavy clay	The sodium adsorption ratio (SAR) provides a means to evaluate the potential base exchange relationships in which soil calcium and magnesium are displaced by sodium present in irrigation water. SAR values can be calculated using the ionic concentrations (in mg/litre) for sodium, calcium and magnesium using the equation below: $SAR = \frac{Na}{\sqrt{0.025 \text{ calcium} + 0.041 \text{ magnesium}}}$ Adjustments in SAR calculations may be necessitated due to rainfall effects and by high levels of bicarbonate in irrigation waters (see SWC 1988). SAR values which exceed these objectives may result in soil permeability/workability problems. With increasing SAR plants of greater salt tolerance may be required.
	clay	
	<6.0 silty clay	
	clay loam	
	silty clay loam	
	<8.0 sandy clay loam	
	sandy clay	
	<10 silt	
	loams	
	sandy loam	
	<12 loamy sand	
	sand	
Total Dissolved Solids (TDS)	700	
Uranium (total)	0.01	
Vanadium (total)	0.1	
Zinc (total)	1.0	

Table 4.6: Chloride Tolerance of Fruit and Woody Crops by Root Uptake*

Rootstocks	Chloride in Irrigation Water (mg/litre)	Cultivars	Chloride in Irrigation Water (mg/litre)
Grapes	710-960	Boysenberry	250
Stone Fruit (peaches, plums, etc.)	180-600	Blackberry	
		Raspberry	
		Grapes	230 - 460
		Strawberry	110-180

* modified from CCREM (1987), Wescot and Ayers (1984).

Table 4.7: Sodium or Chloride Concentrations in Irrigation Water Causing Foliar Damage*

Sensitivity	Ion concentrations (mg/litre)		Affected Crops
	Chloride	Sodium	
Sensitive	<178	<115	Almond, apricot, plum
Moderately Sensitive	178-355	115-230	Grape, pepper, potato, tomato
Moderately Tolerant	355-710	230-460	Alfalfa, barley, corn, cucumber
Tolerant	>710	>460	Cauliflower, safflower, sesame, sorghum, sugar beet, sunflower

* modified from CCREM (1987), Wescot and Ayers (1984).

Table 4.8: Tolerance of Crops to Sodium*

Tolerance	SAR of Irrigation Water	Crop	Conditions
Very Sensitive	2-8	Deciduous fruits	Leaf tip burn, leaf scorch
Sensitive	8-18	Beans	Stunted growth
Moderately Tolerant	18-46	Clover, oats, tall fescue	Stunted because of nutrition and soil structure
Tolerant	46-102	Wheat, lucerne, barley, tomatoes, beets, tall wheatgrass, crested wheatgrass	Stunted because of soil structure.

* Source: CCREM (1987)

SAR: Sodium adsorption ratio (see Table 4.5).

Figure 4.1: *Relationship between salinity and sodium adsorption ratio showing combinations that promote both favourable and unfavourable conditions for permeability of soil.

(After CCREM, 1987)

* with increasing SAR or salinity levels greater salt tolerance in crop species may be required.

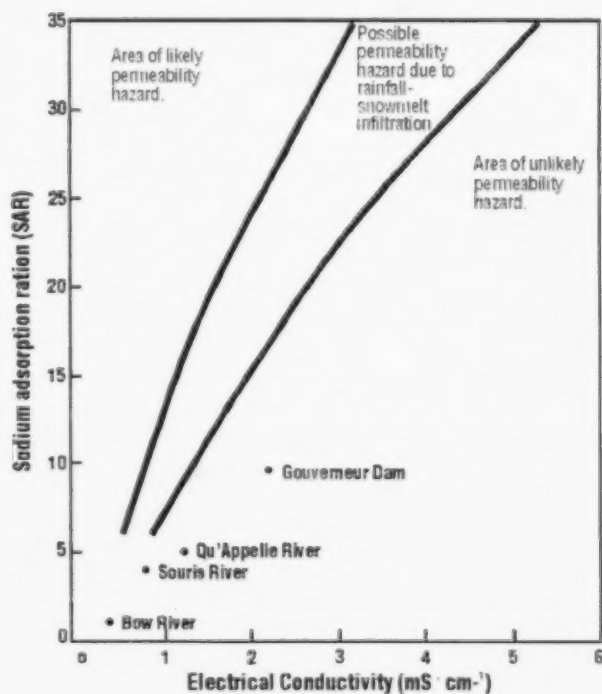


Table 4.9: Tolerance of Selected Crops to Total Dissolved Solids (TDS) in Irrigation Water¹

Degree of Tolerance	Fruits and Berries	Vegetables	Field Crops	Forages
Not tolerant Conductivity <700 TDS <500	Strawberry Raspberry	Bean Carrot	Bean	
Slightly Tolerant Conductivity <1200 TDS <800	Boysenberry Current Blackberry Gooseberry Plum Grape Apricot Peach Pear Cherry Apple	Onion Parsnip Radish Pea Pumpkin Lettuce Pepper Muskmelon Sweet potato Sweet corn Potato Celery Cabbage Kohlrabi Cauliflower	Cowpea Broadbean Flax Sunflower Corn	Clover (alsike, ladino red and strawberry) Berseem clover Forage Corn
Moderately tolerant Conductivity <2200 TDS <1500		Spinach Cantaloupe Cucumber Tomato Squash Brussel sprout Broccoli Turnip		Brome, smooth Alfalfa Big trefoil Beardless Wildrye Vetch Timothy Crested wheatgrass
Tolerant Conductivity <3600 TDS <2500		Beet Zucchini	Rape Sorghum	Oat hay Wheat hay Brome, Mountain, Tall fescue Sweet clover, Reed, Canarygrass Birdsfoot, Trefoil, Perennial Ryegrass
Very tolerant Conductivity <5000 TDS <3500		Asparagus	Soybean Safflower Oats Rye Wheat Sugar beet Barley	Barley hay Tall Wheatgrass

¹ Assumptions and definitions (*Modified from CCREM 1987)

1. The crops within each "tolerant" grouping are listed from least to most tolerant. Actual tolerances will be modified by management, climate and soil conditions.
2. Conductivity is the electrical conductivity of the irrigation water measured as microsiemens per centimetre (uS/cm).
3. TDS means total dissolved solids in units of mg/litre. The conversion factor of conductivity of 1000 = 700 mg/litre has been used to transpose data.
4. Leaching fraction of approximately 15% is maintained. The tolerance tables can be adjusted to increasing or decreasing the leaching fraction.
5. Soil texture ranges from sandy loam to clay with good internal drainage and no uncontrolled shallow water table.
6. Rainfall is low and does not play a significant role in meeting crop demands. The guidelines may be too restrictive for wetter areas.
7. Assume the use of gravity and sprinkler irrigation systems where water is applied infrequently as needed. The crop utilizes 50% or more of the stored available water before the next irrigation. Guidelines are too restrictive for frequent or drip irrigation systems.
8. Each irrigation leaches the upper root zone, and salt accumulation increases with depth. The crop responds to the average salinity in the root zone, and the salt content of the soil solution is about three times that of the irrigation water because of evapotranspiration.
9. Table based on research conducted in California where soils, growing conditions and irrigation practices may differ from those in Saskatchewan.

Table 4.10: Relative Tolerance of Agricultural Crops to Boron *

Tolerance ¹	Concentration of boron in soil water ² (mg/litre)	Agricultural Crops
Very Sensitive	<0.5	Blackberry
Sensitive	0.5-1.0	Peach, cherry, plum, grape, cowpea, onion, garlic, sweet potato, wheat, barley, sunflower, mung bean, sesame, lupin, strawberry, Jerusalem artichoke, kidney bean, lima bean
Moderately sensitive	1.0-2.0	Red pepper, pea, carrot, radish, potato, cucumber
Moderately tolerant	2.0-4.0	Lettuce, cabbage, celery, turnip, Kentucky bluegrass, oat, corn, artichoke, tobacco, mustard, clover, squash, muskmelon
Tolerant	4.0-6.0	Sorghum, tomato, alfalfa, purple vetch, parsley, red beet, sugar beet
Very Tolerant	6.0-15.0	Asparagus

¹Tolerances will vary with climate, soil conditions and crop varieties; values are to be used only as a guideline.

²Maximum concentrations tolerated in irrigation water without reductions in yield or vegetative growth are approximately equal to soil water values or slightly less.

*Modified from CCREM (1987), Wescot and Ayers (1984).

4.2.3.2 Livestock Watering

Livestock, depending upon the species, stage of development, quality of diet and rearing conditions, have different requirements and tolerances to various levels of constituents in waters supplied to them for consumption. The objectives presented in Table 4.11 are intended to afford protection to most livestock species as well as to the consumers of products derived from these livestock.

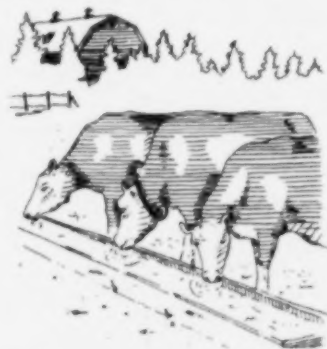
Higher concentrations of constituents addressed in these objectives may be tolerated by some livestock species or by adult animals conditioned to such levels. For instance, higher salt concentrations than the objective level for TDS of 1000 mg/L may be tolerated by some livestock species.

Table 4.12 provides examples of the suitability of various levels of total dissolved solids for livestock.

Table 4.12

provides examples of the suitability of various levels of total dissolved solids for livestock.

In such situations where the quality of water available for livestock watering does not meet the objectives (Table 4.11) livestock producers are advised to contact their local agricultural representative or veterinarian for advice (See Section 6).



4.2.4 Potable Water Supply

The maintenance of good quality drinking water can be achieved both by protecting the raw water supply and by water treatment. It is possible to protect the raw water supply by means of pollution control measures that prevent undesirable constituents from entering the raw water and by good watershed management practices. A wide range of treatment technologies is available by means of which it is possible to produce acceptable drinking water from most raw water sources.

The general water quality objectives in Section 4.1 above will assist in the protection of waters to be withdrawn and treated as a potable supply.

Treatment processes for drinking water should be selected to provide potable and aesthetically acceptable water to the users. For waterworks serving the public, the treated water quality should meet the current Saskatchewan municipal drinking water quality objectives.

Untreated water should not be used for potable purposes.

Table 4.11 Specific Surface Water Quality Objectives for Protection of Use of Water for Livestock Watering

(values are in mg/L unless otherwise stated)

Parameter	Objective Level
Aluminum (total)	5.0
Arsenic (total)	0.5
Bacteria	In intensive and high density livestock operations only high quality water should be given to livestock. Very young animals are much more susceptible to problems from bacterial contamination than mature animals. For specific advice consult the Provincial Veterinary Laboratory or your veterinarian.
Blue-green algae	Avoid waters with heavy growth of blue-green algae
Beryllium (total)	0.1
Boron (total)	5.0
Cadmium (total)	0.02
Chromium (total)	1.0
Cobalt (total)	1.0
Copper (total)	1.0 (cattle) 5.0 (swine/poultry) 0.5 (sheep)
Fluoride (total)	2.0
Lead (total)	0.1
Mercury (total)	0.003
Molybdenum (total)	0.5
Nickel (total)	1.0
Nitrate plus nitrite (NO ₃ plus NO ₂)	100
Selenium (total)	0.05
Sulphate (total)	1000
Total dissolved solids	less than 1000 (see Table 4.12)
Uranium (total)	0.2
Vanadium (total)	0.1

Table 4.12: Influence of Salt (total dissolved solids) Content of Water on Suitability of Water for Livestock Watering*

Total dissolved solids content of water (mg/L)	Suitability for Livestock
<1000	Relatively low level of salinity; excellent for all classes of livestock.
1000-3000	Satisfactory for all classes of livestock and poultry, but some loss in productivity should be anticipated; may cause temporary and mild diarrhea in livestock not accustomed to them or watery droppings in poultry.
3000-5000	Satisfactory for livestock, but may cause temporary diarrhea or be refused at first by animals not accustomed to them; poor waters for poultry, often causing watery feces, increased mortality and decreased growth, especially in turkeys.
5000-7000	Can be used with reasonable safety for beef cattle, sheep, swine and horses; avoid use for pregnant or lactating animals, and dairy cattle; not acceptable for poultry.
7000-10000	Unfit for poultry and probably for swine; considerable risk in using for pregnant or lactating cows, horses or sheep or for the young of these species; in general, use should be avoided, although older ruminants, horses, poultry and swine may subsist on them under certain conditions.
>10000	Risks with these highly saline waters are so great that they cannot be recommended for use under any conditions.

* Table modified after CCREM (1987).

5. Algae and Aquatic Nuisances

"Aquatic nuisances" are those aquatic plants and animals which are present in sufficient numbers to pose problems for people or animals using a particular waterbody or its surrounding environment. Recreational water uses, for example, may be limited by the presence of swimmers' itch, excessive weed growth or algae blooms. One of the most common aquatic nuisances in Saskatchewan surface waters is algae. Algae are tiny plants, most of which are microscopic in size. Although an important component of aquatic ecosystems, certain algae when overabundant can foul beaches and cause water to have an unpleasant colour, taste or odour. Also high densities of blue-green algae that occurs under bloom conditions in surface waters may result in sickness or death among livestock or pets which drink such water.

Various control measures to reduce or eliminate such nuisances as algae, aquatic weeds, leeches, swimmers' itch, and biting insects, are possible. However, aquatic nuisance control activities must be carried out in a manner that will not jeopardize public safety and/or aquatic or terrestrial fauna and flora. Prior to conducting such control activities approval must be obtained from the Department.

The subject of aquatic nuisance identification, control measures, use of chemical/mechanical control, and approval requirements is described in detail in the publication, **A Guide to Aquatic Nuisances and Their Control** (Saskatchewan Environment and Resource Management, 1993).

6. Information Sources

Type of Information	Agency or Source of Information	Phone No. (Regina Unless Noted)
Aquatic Nuisance Control	SERM	787-6181
Effluent Quality/Treatment	SERM	787-6267
Environmental Impact Assessment	SERM	787-6171
Fisheries	SERM	787-2950
Ground Water Hydrogeology	SWC	694-3900 in Moose Jaw
	SRC	933-5496 in Saskatoon
Health Safety of Drinking Water	Dept. of Health	Regional Office or 787-7129 in Regina
Irrigation	SWC	Regional Offices or 867-9925 in Outlook
	Soil Science Dept., U of S	966-6826 in Saskatoon
Livestock	Sk. Ag. & Food	787-6435
Spill Reporting	SERM	1 or 112-800-667-7525 (out-of-province call: 1-306-787-8000)
Water Quality	SERM	787-6238
Water Quantity	SWC	Regional Offices or 694-3959 in Moose Jaw
Water Sampling	SERM	787-6238
Water Treatment	SERM	787-6176

SERM = Saskatchewan Environment and Resource Management

U of S = University of Saskatchewan

SWC = Saskatchewan Water Corporation

SRC = Saskatchewan Research Council

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Explanatory Notes Regarding Water Quality Terms/Parameters

Term	Significance
Aluminum (Al)	-high levels may reduce crop productivity on acid soils.
Ammonia	-toxicity of ammonia to aquatic life relates primarily to the unionized NH_3 form. The proportion of total ammonia ($\text{NH}_3 + \text{NH}_4^+$) present in water as NH_3 increases with pH and water temperature. High levels of ammonia may also exert an oxygen demand in water.
Arsenic (As)	-high levels are toxic to aquatic life, animals and plants.
Assimilation Capacity	-the ability of a waterbody to receive, dilute and absorb effluent constituents without an unacceptable degree of degradation of water quality.
Barium (Ba)	-high levels may be toxic to aquatic life.
Becquerel (Bq)	-a measure of radioactive disintegration rate. 1 Bq equals 27 picoCuries.
Beryllium (Be)	-high levels may be toxic to aquatic life, crops and livestock.
Biochemical Oxygen (BOD ₅)	-a laboratory measure of the amount of dissolved oxygen consumed through biochemical oxidation of organic and/or nitrogenous compounds in water over a 5-day period (at 20°C).
Boron (B)	-high levels may be injurious to irrigated crops to livestock.
Cadmium (Cd)	-toxic to aquatic life, plants, livestock.
Coliforms (Total)	-group of bacteria found in feces, soil, vegetation used as an indicator of bacteriological quality of water. High levels may be indicative of fecal pollution/poor water quality.
Coliforms (Fecal)	-group of bacteria found mostly in feces of warm-blooded animals. Their presence is usually indicative of recent fecal pollution and possible presence of feces-related pathogenic bacteria.
Chloride (Cl)	-high levels of chloride may impart a salty taste to water and may be detrimental for irrigated crops.
Chlorine (total residual)	-may be injurious to fish and aquatic life.
Chromium (Cr)	-toxic to aquatic life, plants, animals.
Cobalt (Co)	-high levels are toxic to aquatic life and may be detrimental to irrigation/livestock watering.
Colour (apparent)	-a measure of the intensity of colour imparted to water by dissolved, colloidal and suspended material; colour is mainly of aesthetic concern.
Copper (Cu)	-toxic for aquatic life at low levels. Higher levels may be injurious for sensitive crops.
Cyanide	-may be toxic to fish, aquatic life at high levels.
Eutrophication	-the aging process of most waterbodies and a measure of the degree of fertilization or enrichment of a waterbody. Eutrophic waterbodies often experience heavy growths of weeds and/or nuisance algae blooms which greatly limit use of the water.
Fluoride (F)	-fluoride may be detrimental to irrigation of sensitive crops; may cause mottling of teeth in livestock.
Iron (Fe)	-high levels may interfere with irrigation, be detrimental for irrigated soils; toxic to sensitive aquatic life.
Lead (Pb)	-toxic to aquatic life and livestock; may reduce crop yields.
Limited Use Zone	-the portion of an effluent mixing zone (see Section 3.2) within which water quality may limit water use but at the boundaries of which surface water quality objectives are achieved.
Lithium (Li)	-high levels may be harmful to barley and other sensitive crops.
Major Ions	-refers to the predominant cations of sodium, calcium, and magnesium, and anions of sulphate, chloride and bicarbonate.
Manganese (Mn)	-may be toxic to plants grown on acidic soils.
Mercury (Hg)	-toxic to aquatic life, plants and animals; accumulates in sediment and food chains.
Molybdenum (Mo)	-may accumulate to toxic levels in livestock forage/feeds hence is of significance to irrigation.
Nickel (Ni)	-high levels may be toxic to aquatic life, crops and livestock.

Nitrate plus nitrite (NO₃ + NO₂)	-high levels may be injurious to young livestock.
Nutrients	-nutrients such as nitrogen and phosphorus may cause profuse growths of weeds and algae in water resulting in rapid eutrophication and use impairment of water.
Oxygen (dissolved)	-an adequate level of dissolved oxygen is required to maintain a proper balance of fish and aquatic life, for natural purification processes, to prevent obnoxious anaerobic conditions. Depletion of dissolved oxygen may result from excessive discharges of organic pollutants.
Pathogens	-organisms which are capable of infecting and causing disease in host plants or animals (e.g. salmonellae bacteria).
Pesticides	-substances used to control or destroy biological pests such as insects, weeds, parasites. Some are toxic to aquatic life at low concentrations; may also taint fish flesh.
pH	-a measure of the hydrogen ion concentration. A pH of 7 indicates neutral conditions on a scale of 0 (acidic) to 14 (alkaline). Extremes of pH (beyond the range of 6.5 to 8.5) are injurious to aquatic life and can cause skin and eye irritation in bathers.
Selenium (Se)	-may be detrimental to irrigation and livestock; toxic to aquatic life.
Silver (Ag)	-toxic to aquatic life.
Sodium (Na)	-of major significance to irrigation as it may be harmful to sensitive crops and to fine textured soils.
Sulphate (SO₄)	-high levels may cause reduced productivity and digestive distress in livestock.
Sulphides	-reduced forms of sulfur including hydrogen sulphide (H ₂ S) which are toxic to fish and aquatic life and which impart a noxious rotten-egg odour to water and may cause corrosion.
Suspended Solids (SS)	-non-colloidal substances suspended in water which may contribute to turbidity, colour. SS is of aesthetic concern. High levels can damage pumps/equipment.
Temperature	-sudden or extreme alterations of water temperature can injure fish, aquatic life.
Toxicity, acute	-refers to the measurement of the response of aquatic organisms to toxic substances. In this report the 96 hr LC ₅₀ test results for aquatic life are used to quantitate acute toxicity.
Turbidity	-a measure of colloidal and suspended solids in water; it influences aesthetics, aquatic life and adds to treatment requirements for consumptive water uses.
Uranium (U)	-high levels may reduce productivity in livestock.
Vanadium (V)	-high levels may reduce growth rates in some livestock.
Zinc (Zn)	-may be toxic to fish, aquatic life and to sensitive crops grown on acidic soils.

